SUMMARY REPORT

September 24, 1985

SUMMARY MUSKOKA '85

INTRODUCTION

"Muskoka '85, an International Symposium on Acidic Precipitation" provided over 600 scientists from 18 countries and 5 continents with a week-long opportunity to review 400 important presentations of research findings. In a milestone conference, the recent work of over 750 authors was reported. Many questions raised at a similar conference in 1980 at Sandefjord, Norway, have been answered and this extensive knowledge will provide legislators with a firmer basis for decision making. A number of new important findings also have emerged:

- Sulphates are confirmed as the primary causal agent in the acidification of aquatic ecosystems.

- Nitrates have emerged as a major consideration in both terrestrial and aquatic systems. In some areas, more nitrogen is added to the soils than can be used by the vegetation. This saturation adds more acidifying ions which further deplete the declining alkalinity.

- The long range transport of airborne pollutants is now accepted as a significant source of pollutant deposition and the relative importance of long range and local pollution at a given site is generally known.

- There is clear evidence of serious declines in health and growth of several species of trees in both Europe and North America, but the reasons are not yet clearly established. Many stresses are evident, including natural causes, silvicultural practices and pollution. The complexity of forest ecosystems suggests that a combination of factors, rather than any one, is responsible for dieback and decline in vigour.

- Recent research has intensified consideration of the influence of ozone, metals and hydrocarbons as well as acidifying precursors as active agents in vegetation damage.

- In designing control strategies, reductions in emissions of wider range of pollutants, especially nitrogen, must be undertaken. Several pollutants, singly or in combination, can play a role and hence must be controlled.

- A 5% decline in United States forest productivity would result in close to $600 million loss of commercial timber. A $200 million loss would occur in eastern Canada alone.

- Recent public opinion polls indicate that United States awareness of acid rain in 1985 matches Canadian awareness at about 90% and that respondents in both countries were generally willing to pay for abatement programs.

Muskoka '85 has also pointed the way to new and intensified research which will improve the baseline data needed to measure the effectiveness of ongoing future abatement programs and emission reductions.

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The following sections present important additional points under the main topics discussed at the conference.

ATMOSPHERIC PROCESSES

- Measurement techniques and the accuracy and detail of data for atmospheric concentrations and deposition have significantly improved during the last five years, and the relationship between emissions in one locality and deposition in another is better known.

- Oxides of nitrogen are important as an acidifying pollutant and as a factor in the formation of ozone which is known to cause damage to forests and crops.

- In snowpacks, nitrates are more abundant than sulphates and contribute to acid shock in the spring.

- The wet and dry deposition of nitrate in Canada and some parts of Europe is equal to that of sulphate.

- Dry deposition may account for 20 to 50% of the removal of sulphates and nitrates from the atmosphere over large regions and up to 70% of the input of pollutants to forests.

- Operational methods for directly measuring dry deposition are not yet available, however estimates can be made using surface characteristics and deposition velocities.

- Pollution deposition resulting from frequent direct contact with clouds and fog is important as an input of acid to high elevation forests.

- At remote locations over the oceans, the concentration of sulphates is remarkably uniform at one-tenth to one-twentieth of the values found in industrialized land areas.

- About 5% of North American sulphur emissions reach Europe, but have little effect upon deposition there.

- Arctic haze is the most pronounced pollution phenomenon in remote northern areas to be documented in recent years. It is caused by mid-latitude emissions of sulphur in North America, Europe and Asia.

- During the last few years, emissions have generally declined in North America and Europe and are coincident with a downward trend in deposition.

- Deposition levels during the 8-month strike at the Sudbury smelters in 1982-1983, indicate that the smelters contribute about 20% of total sulphur deposition within 50 kilometres downwind of Sudbury.

- In the short-term, year-to-year changes in weather patterns will have a greater effect on deposition than emission changes.

- Present models are suitable for formulation of control strategies over broad regions.

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- Long range transport models can predict regional deposition patterns well, but more work is needed for predicting year-to-year variations due to changes in weather patterns and for predicting high pollution episodes. During a large field study in 1982 using inert gas tracers, a Canadian model succesfully predicted the transport of the pollutant cloud, especially during the first 24 hours.

TERRESTRIAL EFFECTS

- Both in eastern North America and Europe, forest decline has occurred where atmospheric deposition is high.

- Acid deposition releases toxic metals, particularly aluminum, in the soil which is carried through the ground water into lakes. Sulphate is the principal anion associated with aluminum mobilization with nitrate occasionally playing an important role, e.g. spring shock.

- The loss of buffering capacity is a slow process but once depleted, the ecosystem acidifies, even if emissions are decreasing.

- Increased nitrogen supplies to forests constitute a stress, increasing nutrient demand and predisposing the trees to frost damage.

- The dry component of deposition is more important than the wet in many forest systems.

- Silver fir and Norway spruce have been particularly affected in Europe and show symptoms involving yellowing and loss of needles, nutrient deficiency in needles and reduction of fine root systems. Forest edges and high altitude sites are especially vulnerable.

- In central Ontario, sulphate in precipitation contributes significantly to the loss of nutrients in forest soils which are central to forest damage.

- Maple decline has been observed recently in eastern Canada. Climate, competition, management, insects, disease and air pollution are possible causes.

- In the eastern United States, there is also evidence of forest decline which can be rapid. Some scientists consider air pollution the most likely cause. In some areas (Vermont, Massachusetts) heavy metal concentrations in soils have increased 50% and pH has decreased.

- In New England and upstate New York, there has been a marked decline of between 13% and 40% in red spruce growth since 1960. A similar reduction in growth of silver fir in Germany began in the mid-1950's.

- Between 1953 and 1984, the pH of the soil humus layer in southwest Sweden has decreased significantly and 50% of the neutralizing capacity has been lost. Acidification of lower horizons has also occurred.

- Half of the forests in Germany and 34% in Switzerland are affected. In northwest Germany, air pollution is the most likely primary cause of forest decline. Although SO_2 emission reductions have occurred in recent years, NO_x emissions are increasing along with associated ozone levels.

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AQUATIC EFFECTS

- Fish populations in Norway continue to decline, even though acid deposition has leveled off. For the period 1978-1983, there was a 30% loss of brown trout and a 12% loss of perch. Since the 1950-1960's, 74% of brown trout and 53% of perch have been lost.

- Salmon kills following episodes of abrupt pH depression have been observed on the west coast of Norway. Many salmon populations along the west coast of Sweden have been lost.

- Lake acidification and fish losses associated with sulphur deposition have been observed in the United Kingdom.

- In Finland, data on effects of acid precipitation of fish are sparse; however, there are reports by local fishermen of losses of fish from clear water lakes.

- Fish losses have been well documented in the Adirondacks, southern Nova Scotia and the La Cloche Mountain lakes in Ontario. Surveys indicate that fish may have been lost in Wisconsin, Michigan, Pennsylvania, Massachusetts, Maine and Quebec.

- Sudden increases in acidity and toxic metal concentrations following snowmelt or episodes of strongly acidic rainfall are regularly documented in Scandinavia and North America. These events have been shown to produce buffering losses and subsequent pH depressions in normally well buffered lakes and streams.

- During episodic events, nitrate is not completely absorbed by the soils and may contribute greatly to the acidity of lakes and streams.

- Episodic associated fish kills are generally a result of ion losses from muscle and plasma and the buildup of aluminum on the gills.

- Shallow ground water systems in Ontario have been observed to lose alkalinity during episodic events. In Scandinavia there has been significant acidification of ground water.

- Dense sphagum mats and growths of algae have been observed on lake bottoms of acidified lakes in Scandinavia. Algae growths have also been observed in similar lakes in North America. Lake-wide odours have been associated with some of these growths.

- Following substantial reductions of SO_2 emissions at Sudbury since the early 1970's, a number of local lakes have recovered significantly.

- Coincident with general SO_2 emission reductions in eastern North America since the late 1970's, the pH level of a number of Nova Scotia rivers has increased.

- Over 3,000 lakes have been limed in Sweden with relatively good success.

- Rapidly flushed lakes and streams cannot be protected and repeated or continuous liming is necessary to prevent reacidification under current deposition levels.

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- Despite an expected 35% reduction in deposition in Scandinavia by the year 2001, it is predicted that there will be further pH depressions in acid lakes and 100% of the salmon populations will be killed if soils are not limed.

- The measured rate of loss of alkalinity in a study lake in Ontario, suggests that large numbers of sensitive lakes will become acidified within two decades if present deposition levels continue.

SOCIO-ECONOMIC ASPECTS

- While good scientific information is essential to improved decision making, political and social values and cost efficiency questions must be considered.

- A decision to delay control action is based on the optimistic view that acid rain damage is reversible, but runs the risk of allowing irreversible damage to occur.

- The economic implications of inaction could be considerable. It is estimated that a loss in forest productivity of 5% would result in annual losses of commercial timber of almost $200 million in eastern Canada. In the United States, comparable losses would be $600 million per year.

- Recreational fishing losses as a result of lower catch rates in the Adirondacks are estimated at up to $12 million per year.

- Damage to culturally significant buildings and monuments in the northeastern United States is estimated at $15-$100 million annually. Damage to other man-made structures is considerably higher.

- One United States utility concluded that "now is the time to move" on strengthening SO_2 emissions control and noted that a cost-effective and flexible approach to controls would be significantly cheaper than mandating specific technology, e.g. scrubbers.

- Major reasons for inaction in the United States include is the cost of controls, the question of who will pay, and competing regional interests.

- The Ontario Government is developing abatement strategies based on a deposition loading target established for Eastern Canada of 20 kg of sulphate/ha/year (18 lb/acre), a long range atmospheric transport model and an assessment of industry and community impacts.

- A comparative survey of schoolchildren residing in polluted and non-polluted towns in Canada demonstrated a direct correlation between respiratory problems and higher episodes of SO_2, sulphates and nitrates.

- A survey of public opinion polls has shown that over 90% of the people in Canada and the United States are aware of acid rain; a vast increase in the U.S. in the past four years. There is substantial support for emissions control in both countries and a willingness to contribute to the costs of controls. Public dissatisfaction is expected to grow until visible control action is taken.

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POLICY IMPLICATIONS

- Acid deposition is a major example of how man is changing the chemical composition of our planet. Solutions for policy-makers are interrelated and enormously complex. Co-operative decisions, both national and international, are required, since acid rain does not respect political boundaries.

- Solutions to the acid rain problem are complicated however, by a number of factors: a) the damage frequently occurs in areas remote from the sources of pollution; b) the costs of reducing emissions may be significant and their allocation a source of dispute; and c) opinions vary as to which pollutants should be controlled first.

- Since acid rain is a long range transboundary air pollution problem, the "downwind" jurisdictions generally advocate stronger control action than those "upwind", where major sources of pollution are located. Hence, policies in Canada and the United States have diverged in recent years and there is a need to resume work on an agreement to reduce transboundary air pollution.

- Recent developments in the state of the science have direct implications for policy. For example, oxides of nitrogen are increasingly important in forest damage, in episodic acidic surges in lakes and streams and in the formation of ozone. The role of SO_2 and sulphates in damaging aquatic ecosystems and reducing visibility has been confirmed, and there is strong evidence respecting their contribution to forest and materials damage. This evidence strongly argues for the need for additional and parallel controls of NO_x and SO_x emissions.

- The conference findings also suggest new directions for research. These include: field testing of laboratory results which have demonstrated problems of forest regeneration; the development of a better understanding of the relationship between climatology and forest effects; improvement of atmospheric modelling techniques; understanding ground water acidity; and explaining the role of episodic cloud and fog events with respect to forest damage.

- Research and emissions control action should both continue apace.